(4) **Mache, H.** Ueber den Druck in Gasen unter dem Einfluss starker elektromotorischer Kräfte. Sitzungsb., K. Akad. d. Wissensch. Abt. IIa, Wien, 1898, **107**: 708.

**Haschek, E. & Mache, H.** Ueber den Druck im Funken. ibid., 1898, **107**; Annalen d. Physik (Wied.), N. F., 1899, **68**: 740.

(5) **Mach, E. & Weltrubsky, J. v.** Ueber die Formen von Funkenwellen. Sitzungsb., K. Akad. d. Wissensch., Wien, 1878, **78**: 551.

(6) **Wolff** *in* Annalen d. Physik (Wied.), N. F., 1899, **69**: 329.

(7) **Lummer.** Ueber die Theorie des Knalles. Schlesischen Gesells. f. vaterl. Kultur, II. Abt., 1905, **83**. Jhrb., p. 2.

(8) **Mach, E. & Gruss, G.** Optische Untersuchung der Funkenwellen. Sitzungsb., K. Akad. d. Wissens., Abt.IIa, Wien, 1878, **78**: 479.

(9) **Dörr, J. N.** Ueber die Fernwirkung der Explosion am Steinfelde bei Wiener-Neustadt (1912, Juni 7). Sitzungsb., K. Akad. d. Wissens., Kl. IIa, Wien, 1913, **122**: 1683.

(10) **Walter, B.** *in* Phys. Ztschr., 1902, **3**:168; *also* Hamburger wissens. Anstalten, Jhrb. 1903, **20**.

## THE PLACE OF FORESTRY AMONG NATURAL SCIENCES.[1]

By HENRY S. GRAVES, Chief, United States Forest Service.

[Extracts from an address delivered before the Washington Academy of Sciences, Dec. 3, 1914.]

Forestry as a natural science deals with the forest as a community in which the individual trees influence one another and also influence the character and life of the community itself. As a community the forest has individual character and form. It has a definite life history; it grows, develops, matures, and propagates itself. Its form, development, and final total product may be modified by external influences. By abuse it may be greatly injured, and the forest as a living entity may even be destroyed. It responds equally to care, and may be so molded by skillful treatment as to produce a high quality of product and in greater amount and in a shorter time than if left to nature. The life history of this forest community varies according to the species composing it, the density of the stand, the manner in which the trees of different ages are grouped, the climatic and soil factors which affect the vigor and growth of the individual trees. The simplest form of a forest community is that composed of trees of one species and all of the same age. When several species and trees of different ages occupy the same ground, the form is more complex, the crowns overlapping and the roots occupying different layers of the soil. Thus, for instance, when the ground is occupied with a mixed stand of Douglas fir and hemlock, the former requiring more light occupies the upper story, and because of its deeper root system extends to the lower-lying strata of the soil. The hemlock, on the other hand, which is capable of growing under shade, occupies the under story, and having shallow roots utilizes largely the top soil. * * *

In a forest there is altogether a different climate, a different soil, and a different ground cover than outside of it. A forest cover does not allow all the precipitation that falls over it to reach the ground. Part of the precipitation remains on the crowns and is later evaporated back into the air. Another part, through openings in the cover, reaches the ground, while a third part runs down along the trunks to the base of the trees. Many and exact measurements have demonstrated that a forest cover intercepts from 15 to 80 per cent of precipitation, according to the species of trees, density of the stand, age of the forest, and other factors. Thus pine forests of the North intercept only about 20 per cent, spruce about 40 per cent, and fir nearly 60 per cent of the total precipitation that falls in the open. The amount that runs off along the trunks in some species is very small—less than 1 per cent. In others—for instance, beech—it is 5 per cent. Thus if a certain locality receives 50 inches of rain, the ground under the forest will receive only 40, 30, or 20 inches. Thus 10, 20, and 30 inches will be withdrawn from the total circulation of moisture over the area occupied by the forest. The forest cover, besides preventing all of the precipitation from reaching the ground, similarly keeps out light, heat, and wind. Under a forest cover, therefore, there is altogether a different heat and light climate and a different relative humidity than in the open. * * *

The effect which trees in a stand have upon each other is not confined merely to changes in their external form and growth; it extends also to their internal structure. The specific gravity of the wood, its composition, and the anatomical structure which determines its specific gravity differ in the same species and on the same soil and in the same climate, according to the position which the tree occupies in the stand. Thus in a 100-year-old stand of spruce and fir the specific gravity of wood is greatest in trees of the third crown class (intermediate trees). The ratio of the thick wall portion of the annual ring to the thin wall of the spring wood is also different in trees of different crown classes. The difference in the size of the tracheids, in trees of different crown classes, may be so great that in one tracheid of a dominant tree there may be placed three tracheid cells of a suppressed tree. The amount of lignin per unit of weight is greater in dominant trees than in suppressed trees. * * *

Forestry, unlike horticulture or agriculture, deals with wild plants scarcely modified by cultivation. Trees are also long-lived plants; from the origin of a forest stand to its maturity there may pass more than a century. Foresters therefore operate over long periods of time. They must also deal with vast areas; the soil under the forest is as a rule unchanged by cultivation, and most of the cultural operations applicable in arboriculture or agriculture are entirely impracticable in forestry. Forests, therefore, are largely the product of nature, the result of the free play of natural forces. Since the foresters had to deal with natural plants which grew under natural conditions, they early learned to study and use the natural forces affecting forest growth. In nature the least change in the topography, exposure, or depth of soil, etc., means a change in the composition of the forest, in its density, in the character of the ground cover, and so on. As a result of his observations the forester has developed definite laws of forest distribution. The forests in the different regions of the country have been divided into natural types with corresponding types of climate and site. These natural forest types, which, by the way, were also developed long before the modern conception of plant formations came to light, have been laid at the foundation of nearly all of the practical work in the woods. A forest type became the silvicultural unit, which has the same physical conditions of growth throughout, and therefore requires the same method of treatment. The manner of growth and the method of natural regeneration, once developed for a forest type, hold true for the same type no matter where it occurs.

After the relation between a certain natural type of forest and the climate and topography of a region has been established, the forest growth becomes the living expression of the climatic and physical factors of the locality. Similarly, with a given type of climate and locality it is possible for the forester to conceive the type of forest which would grow there naturally. The forester, therefore, may speak of the climate of the beech forest, of the Engelmann spruce forest, of the yellow-pine forest. Thus, if in China, which may lack weather observations, we find a beech forest similar to one found

[1] Reprinted from Journal, Wash. Acad. Sci., Jan. 19, 1915, 5:41-56.

in northern New York, we can be fairly certain of the climatic similarities of the two regions. More than that, a type of virgin forest growth may serve as a better indication of the climate of a particular locality than meteorological records covering a short number of years. A forest which has grown on the same ground for many generations is the result not of any exceptional climatic cycle, but is the product of the average climatic conditions that have prevailed in that region for a long time. It expresses not only the result of one single climatic factor, but is the product of all the climatic and physical factors together. Similarly, the use of the natural forest types for determining the potential capacity of the land occupied by them for different purposes, is becoming more and more appreciated. When the climatic characteristics of a certain type of forest, for instance, those of Engelmann spruce in the Rocky Mountains, is thoroughly established, the potential capacity of the land occupied by it for agriculture, grazing, or other purposes is also largely determined.

Observations of the effect of climate upon forest growth naturally brought out facts with regard to the effect of forests upon climate, soil, and other physical factors and led to the development of a special branch of meteorology, known as forest meteorology, in which the foresters have taken a prominent part. While there are some phases in forest meteorology which still allow room for disagreement, some relationships established by foresters are widely accepted. One of these is the effect which forests have upon local climate, especially that of the area they occupy and of contiguous areas. Every farmer who plants a windbreak knows and takes advantage of this influence. Another relation is that between the forest and the circulation of water on and in the ground, a relation which plays such an important part in the regimen of streams. Still a third one, as yet beyond the possibility of absolute proof, is the effect of forests in level countries, in the path of prevailing winds, upon the humidity and temperature of far-distant regions lying in their lee. * * *

## WHY SOME WINTERS ARE WARM AND OTHERS COLD IN THE EASTERN UNITED STATES.

By W. J. HUMPHREYS, Professor of Meteorological Physics.

[Dated Weather Bureau, Washington, Feb. 1, 1915.]

### INTRODUCTION.

As every one knows, no two winters are exactly alike. Even a short memory will convince one living in the eastern United States that here some winters are much colder than the average while others are exceptionally mild. Of course, many other places experience similar differences in the severity, or, if one prefers, geniality of their seasons, and to each there necessarily belongs an interesting study of how these differences occur and why. In the present paper, however, only exceptional winters in the eastern United States will be considered.

### LIST OF ABNORMAL WINTERS.

An examination of the climatological records shows that beginning with December, 1880, the earliest date for which we have sufficient and convenient data for the present study, the eastern United States has had a number both of exceptionally mild and of exceedingly cold winter months. The more pronounced of these are listed in Table 1, in which the numbers give, roughly, each the average temperature departure for the month in question, over the eastern United States, from the corresponding normal.

TABLE 1.—*Excessive monthly temperature departures in the eastern United States.*

| Winters. | December. | January. | February. | March. |
|---|---|---|---|---|
| | °F. | °F. | °F. | °F. |
| 1880-81 | −4 | −4 | | −3 |
| 1881-82 | 5 | 4 | 5 | |
| 1883-84 | | | 6 | |
| 1884-85 | | | −6 | −6 |
| 1885-86 | | −4 | | |
| 1886-87 | −5 | | | |
| 1887-88 | | | | −4 |
| 1889-90 | 7 | 9 | 9 | |
| 1890-91 | | | 6 | |
| 1891-92 | 6 | | | |
| 1892-93 | | −8 | | |
| 1893-94 | | 4 | | |
| 1894-95 | | | −7 | |
| 1897-98 | | | | 5 |
| 1900-1901 | | | −5 | |
| 1903-04 | −5 | −5 | −5 | |
| 1904-05 | −4 | | −7 | |
| 1908-09 | | | 4 | |
| 1911-12 | 5 | −5 | | |
| 1912-13 | 4 | 9 | | 5 |

### PREPONDERANCE OF LOCAL OVER GENERAL CAUSES.

If we omit isolated months and consider only entire winter seasons, it will appear that usually the temperature departure of the eastern United States has been of the same sign as that of the whole world, which in turn seems to depend upon the combined influence of sun spots and volcanic dust (1). This general agreement shown in Table 2, it should be remembered, is between the annual temperature departure of the world as a whole and the winter temperature departure of only the eastern United States. Therefore, agreements and disagreements in their signs, since the periods are not the same and since the local seasonal departure often is from 10 to 20 fold that of the world-wide annual departure, probably have but little meaning. Nevertheless, if the number of cases were sufficiently large there probably would be rather more instances where the signs of the departures were the same than where they were different; hence, though the period covered is too short satisfactorily to test even this point, it seems only fair to give the comparison table for whatever, if anything, it may be worth.

TABLE 2.—*Comparison of seasonal local (winter, eastern United States) and annual world-wide temperature departures.*

| Date. | Winter, eastern United States. | Year, world. | Comparison. |
|---|---|---|---|
| 1880-81 | Cold | Warm | Disagreement. |
| 1881-82 | Warm | do | Agreement. |
| 1884-85 | Cold | Cold | Do. |
| 1889-90 | Warm | Warm | Do. |
| 1903-04 | Cold | Cold | Do. |
| 1912-13 | Warm | Insufficient data. | (?). |

On its face this table indicates decidedly more agreements than disagreements, but, as already stated, the local winter temperature departures under consideration are so many times greater than the world-wide annual departures that the causes of the latter, though, of course, having their influence, clearly can not be the chief cause of the former. Neither do the former, pertaining to but